MULTIMEDIA UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

ETN2016 – ANALOG COMMUNICATIONS

(All Section / Groups)

19 OCTOBER 2019
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 7 pages (including the cover page) with 4 Questions only.

2. Attempt all of the **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Consider a periodic signal $s(t)$ shown in Figure Q1(a).

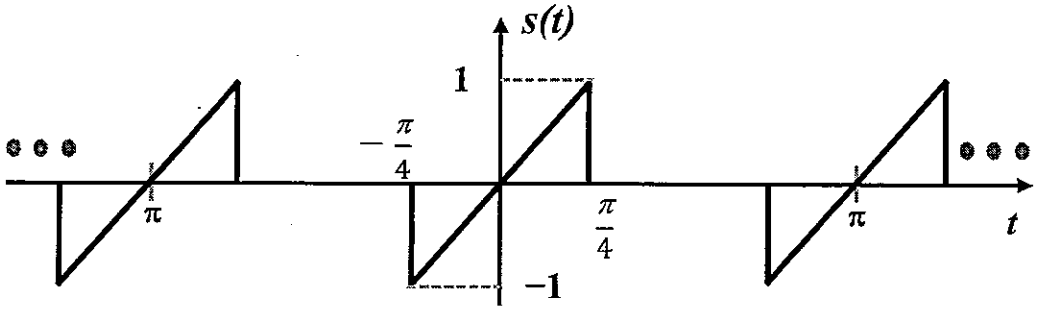

Figure Q1(a) : Periodic signal $s(t)$.

(i) Determine the trigonometric Fourier series of $s(t)$.

[12 marks]

(ii) Sketch the single-sided magnitude spectrum of $s(t)$ up to the 6th harmonic, i.e., n = 0, 1, 2, 3, 4, 5, 6 where $f = nf_0$ is the nth harmonic frequency, $f_0 = \frac{1}{T_0}$, and T_0 denotes the period of $s(t)$.

[3 marks]

(iii) Sketch the double-sided phase spectrum of $s(t)$ for n = -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6 where $f = nf_0$ is the nth harmonic frequency, $f_0 = \frac{1}{T_0}$, and T_0 denotes the period of $s(t)$.

[3 marks]

(b) If $y(t)$ has Fourier Transform, $Y(f) = e^{-j6\pi f}$. Determine the Fourier transform of the followings:

(i) $z_1(t) = e^{jt}.y(t+2)$.

[3 marks]

(ii) $z_2(t) = y(3t)$.

[2 marks]

(iii) $z_3(t) = \frac{dy}{dt}$

[2 marks]

Continued .....

Question 2

(a) Explain briefly FOUR (4) disadvantages of amplitude modulation (AM).

[8 marks]

(b) In a Double Sideband Large Carrier (DSB-LC) modulation scheme, a modulating signal $s_m(t) = 3\cos(200\pi t)$ is used to modulate a carrier signal $s_c(t) = 4\cos(4\times10^6\pi t)$. The time domain mathematical expression of the modulated signal is $s_{\tilde{m}}(t) = [4 + 3\cos(200\pi t)]\cos(4\times10^6\pi t)$.

(i) Calculate the modulation index. State whether the signal is over-modulated or under-modulated.

[2 marks]

(ii) Plot and label the double-sided amplitude spectrum of the modulated signal $s_{\tilde{m}}(t)$. Note: The horizontal axis should be in Hz.

[3 marks]

(iii) Calculate the power efficiency of this transmission.

[4 marks]

(c) Consider an information signal with the magnitude spectrum and a Single Sideband (SSB) transmitter shown in Figure Q2(c). Suppose we want to transmit the signal across the channel using SSB modulation scheme.

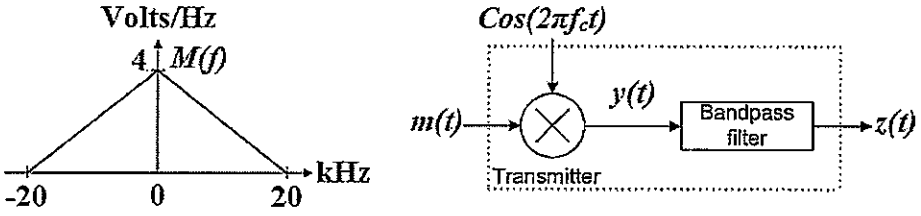

Figure Q2(c) : Magnitude spectrum *M(f)* and a SSB transmitter.

(i) Sketch the magnitude spectrum of $y(t)$.

[2 marks]

(ii) Sketch the magnitude spectrum of $z(t)$ if the upper sideband is transmitted.

[2 marks]

(iii) Give one advantage of SSB modulation scheme compared with Double Sideband Large Carrier (DSB-LC) modulation scheme. State your reason.

[2 marks]

(iv) Give one disadvantage of SSB modulation scheme compared with Double Sideband Large Carrier (DSB-LC) modulation scheme. State your reason.

[2 marks]

Continued .....

Question 3

(a) Consider a frequency-modulated (FM) signal that is expressed as follows:

$$x(t)=10\cos\left\{(2\pi)(1\times10^{6}t)+2\sin(2\times10^{3}\pi t)\right\}$$

Assume that $x(t)$ is supplied to a load of 1 ohm.

(i) Determine the carrier frequency and the message signal bandwidth.

[2 marks]

(ii) Determine the instantaneous frequency, $f_i(t)$, the maximum frequency deviation, Δf, and the modulation index, β.

[4 marks]

(iii) Determine the average power of the modulated signal, P_{total}.

[2 marks]

(iv) By using the Carson's rule, calculate the bandwidth of modulated signal.

[2 marks]

(v) By using the table of Bessel function of the first kind, compute the amount of transmission power that falls in the sideband.

[3 marks]

(vi) The frequency-modulated signal $x(t)$ is passed through an ideal bandpass filter with center frequency of 1 MHz, bandwidth of 7 kHz, and unity gain. Determine the number of sidebands that will pass through the bandpass filter without being attenuated and the average power measured at the output of the filter.

[6 marks]

(b) Briefly explain THREE (3) advantages and THREE (3) disadvantages of FM over its AM counterpart.

[6 marks]

Continued .....

Question 4

(a) An RF signal with input power (P_{in}) of 10 dBm and frequency (F_{RF}) of 900 MHz is connected to a receiver front-end shown in Figure Q4(a), with the given insertion loss (IL) of the filters, gain (G) of the amplifier and conversion gain (CG) of the mixer.

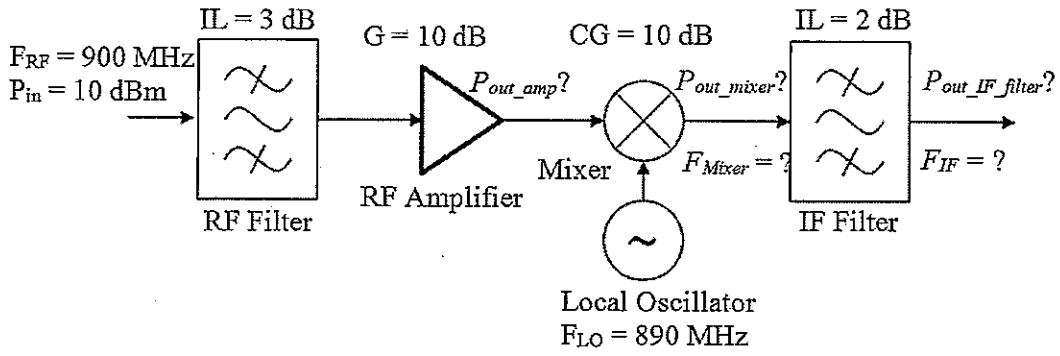

Figure Q4(a) : Block diagram of a receiver front-end.

(i) Briefly explain the usages of RF and IF filters used in this receiver.

[4 marks]

(ii) Determine the overall gain of this receiver (in both normal and dB scale) and its respective image frequency.

[4 marks]

(iii) Determine the RF power that will be measured at the RF amplifier output (P_{out_amp}, in mW).

[2 marks]

(iv) List all the possible frequencies appeared after the mixer. Next, determine the down-converted IF frequency, F_{IF}.

[3 marks]

(v) Determine the IF power that will be measured at the mixer output (P_{out_mixer}, in mW).

[2 marks]

(vi) Determine the IF power that will be measured at IF filter output ($P_{out_IF_filter}$, in mW).

[2 marks]

(b) Explain the meaning of Signal-to-Noise Ratio (SNR) in a typical analog communication system. Then, with suitable diagrams explain briefly TWO (2) methods used in commercial frequency modulation (FM) broadcasting for improving the SNR at both the transmitter and receiver.

[8 marks]

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APPENDIX

Trigonometric Identities and Integral

$$\sin A \sin B = \frac{1}{2}\left[\cos(A-B) - \cos(A+B)\right]$$

$$\cos A \cos B = \frac{1}{2}\left[\cos(A+B) + \cos(A-B)\right]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\int x(\sin ax)dx = \frac{1}{a^2}(\sin ax - ax.\cos ax)$$

$$\int x(\cos ax)dx = \frac{1}{a^2}(\cos ax + ax.\sin ax)$$

Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t) + bx_2(t) \Leftrightarrow aX_1(f) + bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$
Time Shifting	$x(t - t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f - f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n}x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n}X(f)$
Time Integration	$\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f} + \frac{1}{2}X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$

Continued .....

Table of Bessel functions of the first kind

	$J_n(\beta)$							
n	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1.0$	$\beta = 2.0$	$\beta = 3.0$	$\beta = 5.0$
0	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178
1	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328
2	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047
3		0.001	0.003	0.007	0.020	0.129	0.309	0.365
4				0.001	0.002	0.034	0.132	0.391
5						0.007	0.043	0.261
6						0.001	0.011	0.131
7							0.003	0.053
8								0.018
9								0.006
10								0.001

End of Paper